Clean Set of Claims

1. A method for reducing the amount of computations required to create a sound signal representing one or more sounds originating at a plurality of discrete positions in space, where the signal is to be perceived as simulating one or more sounds at one or more selected positions in space with respect to a listener, comprising the steps of:

(a) determining a special characteristic function for a position in space at which sound originating at a plurality of positions in space is to be received, wherein said characteristic function represents a head-related impulse response;

(b) applying said characteristic function as a filter to the signal representing sound to produce a filtered signal; and

(c) converting the filtered signal to a sound wave and producing the sound wave for a listener;

wherein a special characteristic function is determined for a selected number of samples and a selected number of eigen values.

8. A method of reducing the amount of computations required to create a sound signal representing one or more sounds originating at a plurality of discrete positions in space, where the signal is to be perceived as simulating one or more sounds at one or more selected positions in space with respect to a listener, comprising the steps of:

(a) determining a spatial characteristic function for a position in space at which sound originating at a plurality of positions in space is to be received, wherein said characteristic function represents a head-related impulse response;

D2

(b) applying said characteristic function as a filter to the signal representing sound to produce a filtered signal; and

(c) converting the filtered signal to a sound wave and producing the sound wave for a listener;

wherein the spatial characteristic function is determined for a selected number of N samples and a selected number of M eigen values and wherein the model filter function for an azimuth position θ and an elevation position φ of sound originating in a spherical coordinate system about the position of sound measurement as the origin has the form

$$y(n) = \sum_{m=1}^{M}\left[\sum_{k=1}^{K} w_m(\theta_k,\varphi_k)s_k(n)\right]q_m(n) \quad 9(c)$$

where s represents a sound source, K represents the number of independent sound sources, $w_m(\theta,\varphi)$ are the weighting factors, and $q_m(n)$ is a vector representing an orthonormal basis for a head-related impluse function.

9. Apparatus for providing sound created by a sound source to a listener which simulates the sound source at a selected position in space with respect to the listener, comprising:

D3

(a) an input for receiving a signal representing sound originating at a plurality of positions in space, said plurality of positions including multiple reflections, multiple sources without reflections, and multiple sources with multiple reflections;

(b) a left channel and a right channel, wherein each channel comprises a filter array for applying a filter to the signal received by the input to provide a filtered signal, the filter comprising a linear function including a spatial component which comprises a head-related impulse response;

(c) an output for converting the filtered signals from said channels to a binaural sound and for producing the sound for a listener.

21. An apparatus for efficiently simultaneously processing a simulation of a plurality of sound signals in a three dimensional space, each channel within said apparatus comprising:

D4

at least one delayer for delaying a sound source signal;

at least one attenuator for attenuating a sound source signal;

a plurality of filters for filtering said attenuated sound signal;

a plurality of weighting elements to weight said filtered sound signals; and

a summer for summing said filtered sound signals;

wherein said plurality of filters remain constant, with at least one of said at least one delay element, said at least one attenuator, and said plurality of weighting elements adapted to change a perceptive position of said sound source signal to a listener; and

wherein said plurality of sound signals comprise multiple reflections, multiple sources without reflections, and multiple sources with multiple reflections.

23. A method for efficiently simultaneously processing a simulation of a plurality of sound signals in a three dimensional space, each channel within said apparatus comprising:

delaying a sound source signal;

attenuating a sound source signal;

D5

filtering said attenuated sound signal;

weighting said filtered sound signals; and

summing said filtered sound signals;

wherein said filtered attenuated sound signal remains constant, with at least one of said delayed sound source signal, said attenuated sound source signal, and said weighted filtered sound signals are adapted to change a perceptive position of said sound source signal to a listener; and

wherein said plurality of sound signals comprise multiple reflections, multiple sources without reflections, and multiple sources with multiple reflections.

25. An apparatus for efficiently simultaneously processing a simulation of a plurality of sound signals in a three dimensional space, each channel within said apparatus comprising:

means for delaying a sound source signal;

D6

means for attenuating a sound source signal;

means for filtering said attenuated sound signal;

means for weighting said filtered sound signals; and

means for summing said filtered sound signals;

wherein said means for filtering said attenuated sound signal remains constant, with at least one of said means for delaying said sound source signal, said means for attenuating said sound source signal, and said means for weighting said filtered sound signals are adaptived to change a perceptive position of said sound source signal to a listener; and

wherein said plurality of sound signals include multiple reflections, multiple sources without reflections, and multiple sources with multiple reflections.